means of a ladder, since it is situated on the side of hill. * * * The ice is formed from a peculiar cold mist which comes through openings found all the way from the top to the bottom of the 40-foot shaft. As soon as the warm weather arrives frost appears on the walls of the shaft and soon tiny icicles form rapidly, until in the warmest weather huge icicles, often 2 feet thick, reach from the platform at the top, to the bottom of the mine. The ice begins forming in May, and in October the thaw sets in. A shelter was erected over the mine some time ago; but it had to be removed because the ice melted. * * * The mine has been used as a cold storage plant by the wife of the farmer, and she claims that eggs have been kept seven months in the natural refrigerator and at the end of that period found to be in perfect condition. During the summer the temperature of the mine ranges from 25° to 30° F. above zero. This mine, [in winter] notwithstanding the fact that it is open at the top, is warm enough to keep vegetables without freezing."

FORECASTING TIDE STAGES IN THE HARBOR AT PORTLAND, OREG.

EDWARD LANSING WELLS, Meteorologist.

[Dated: Weather Bureau, Portland, Oreg., Oct. 16, 1919.]

The ebb and flow of the tide affect the stage of water in the Columbia River for some distance above the mouth of the Willamette, probably as far as Cascade Locks, and at times affect the stage of the Willamette to the foot of the falls at Oregon City. Cascade Locks is about 150 miles from the mouth of the Columbia, and Oregon City is about 120 miles.

The zero of the river gage at Portland is less than 1 foot above mean sea level. The maximum range of the tide at Astoria, 99 miles below Portland, is about 12 feet. The maximum range of the tide at Portland is between 3.5 and 4 feet. When the river at Portland stands at 9 feet or higher, the tide effect is seldom noticeable. Figure 1 shows graphically the rise and fall of the river during a typical week. It will be seen that, owing to the fact that the time required for the tide to travel from Astoria to Portland is nearly equal to the interval between the high and low tides, the actual water level at Astoria is occasionally higher than at Portland. This condition is apparently never sufficiently pronounced to cause a reversal or even a cessation of the current in the Columbia, but at low-water stages there is a noticeable reversal of the current in the lower reaches of the Willamette.

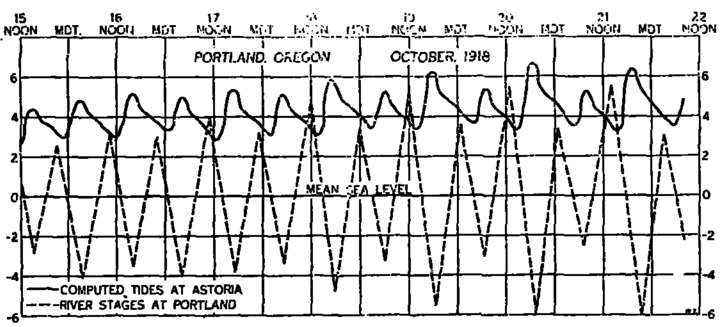

FIG. 1.—Tides in the Columbia River, Oct. 15-22, 1918.

During settled weather, when the normal stage of water in the Columbia and Willamette is low, as during the late summer and early fall of 1918 and 1919, it has been found that high tide at Portland occurs about 6 hours later than at Astoria, and that the maximum stage at Portland, based on the zero of the river gauge, will be about 45 per cent to 55 per cent of the computed stage at Astoria, based on mean lower low water, which is the datum used in current tide tables. Figure 2 shows the relation for the month of October, 1918.

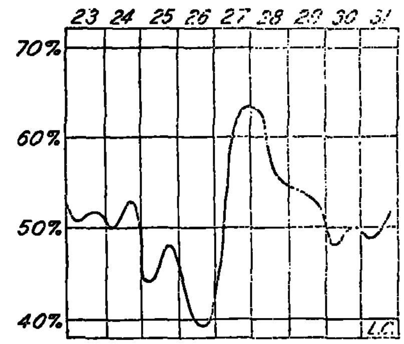

FIG. 2.—Relation of tide at Portland to computed tide at Astoria, Oct. 23-31, 1918.

However, when high winds occur along or near the coast, the actual stages at Astoria vary considerably from the computed tides, and at such times accurate predictions for Portland can not be made. Weather maps of October 25–27, indicate an increasing pressure gradient that favored on-shore gales attending the extreme variation that occurred on October 26 and 27, as indicated in figure 2. It appears that as the storm approaches, the offshore winds hold the water back; later, as the storm advances, the winds change, piling the water up. This heaping up of the water is doubtless due more to the action of winds well out to sea than to winds along the immediate coast.

Arrangements were made to install a recording tide gauge at Astoria, for use in this connection, but conditions arising after the close of the war made this impracticable

BAROMETRIC PRESSURE, WINDS, AND STORMS OF THE PACIFIC OCEAN.[1]

By EDWARD A. BEALS.

[Abstract.]

In January there are two areas of high pressure centered, respectively, midway between Honolulu and San Francisco and off the coast of Chile, and three areas of low pressure centered over the Aleutian Islands, the south polar regions, and Australia. In July the Aleutian LOW disappears and there is a HIGH over Australia. These formations are subject to seasonal variations in position and magnitude, because of the shifting apparent position of the sun in the heavens. They are caused by the familiar inequality of the heating of the land and water areas, and by dynamical causes inherent in the planetary circulation.

The usual system of spirally flowing winds surrounds these formations. The proximity of the North Pacific HIGH to the American coast is the cause of the rainless

[1] Presented at the Pasadena meeting of the A. A. A. S., June, 1919. Published in full by University of California Press, 1920.

summers in California, Oregon, and Washington, as it brings air from the colder portion of the ocean in over the land, which, as soon as it is reached, increases the temperature of the air, and thereby its capacity for retaining water vapor in an invisible state. The dryness of the land adjacent to the South Pacific HIGH is even greater than in the Northern Hemisphere, for the southern HIGH is less subject to changes from summer to winter than the northern one.

The tropical regions of the Pacific are under the influence of the trades, which show seasonal variations, and the monsoons.

This general system of air circulation is frequently invaded by storms, both tropical and extratropical, of which the Pacific has its full quota. But little is known, however, of the storms of either kind which occur in the Southern Hemisphere. The storms of the Northern Hemisphere are strongly influenced by the semi-permanent "centers of action," e. g., the Aleutian LOW and the North Pacific HIGH.

There is a great need for additional information as to the centers of action of the Pacific and the changes taking place in them; this information could be obtained by the establishment of more first-class meteorological stations on the islands and coasts of the Pacific; by maintaining cruisers equipped for meteorological observations, including aerological observations, at permanent stations or within limited areas; and by enlisting every Pacific ship for the purpose of taking observations, including those of the temperature and salinity of the water. Progress along all of these lines has already commenced.—*E. W. W.*

THE DISTRIBUTION OF TEMPERATURES AND SALINITIES, AND THE CIRCULATION, IN THE NORTH PACIFIC OCEAN.[1]

By GEORGE F. MCEWEN.

[Abstract.]

Observation shows that, by reason of well-known causes, no part of the ocean is motionless. Observations of temperature and salinity are of great value in determining the details of the oceanic circulation, for the presence of water differing significantly in any property from that corresponding to local conditions indicates a flow of water from regions where different conditions prevail. The vertical and horizontal flow of water is the factor most concerned in modifying the simple temperature distribution to be expected from the variation of solar radiation with respect to latitude and from the distribution of land and water. The thermal equator is at latitude 10° N.; most of the surface of the Atlantic from latitudes 20° to 60° N. is from 1° to 4° above the normal temperature at corresponding latitudes, and the North Pacific averages 2° colder than the North Atlantic; greater temperature anomalies are found in many small areas. The distribution of salinity is even more irregular, depending upon more factors. In both the northern oceans the maximum surface salinity is found in the Horse latitudes, but it is notably higher in the Atlantic. In some regions, e. g., the Bahamas, the salinity decreases continually from the surface to the bottom, while in others, e. g., the North Pacific off southern California, it decreases only in the upper 40 meters, and increases from there to the bottom.

A great desideratum is a systematic study of the North Pacific comparable with [or even more extensive than] that which has been made of the North Atlantic. Observations now available, though inadequate, supply the following general information:

Owing to the well-known difference in the heating effects of insolation upon land and upon water, the water of the North Pacific, from the Equator to 45°, tends to be colder than land, especially in summer, and that north of 45°, especially in winter, tends to be warmer than land; these tendencies in part give rise, respectively, to the HIGH about 1,500 miles west of San Francisco, and to the Aleutian LOW. The resulting winds cause the North Pacific oceanic circulation to be, in its main outlines, a clockwise eddy lying between the Equator and latitude 45°. Great modifications as to details and to seasonal variations exist.

The California current is shown to be an upwelling of cold bottom water, which the author holds to be continuous with a slow northward drift of cold bottom water from the Antarctic. (For an account of how this influences the California climate, see McEwen, MONTHLY WEATHER REVIEW, 1914, 42, 14–23.).—*E. W. W.*

[1] Presented at the Pasadena meeting of the A. A. A. S., June, 1919. Published in full by University of California Press, 1920.

A PHYSICAL THEORY OF OCEAN OR RESERVOIR TEMPERATURE DISTRIBUTIONS REGARDED AS EFFECTS OF SOLAR RADIATION, EVAPORATION, AND THE RESULTING CONVECTION.[1]

By GEO. F. MCEWEN.

[Author's abstract.]

Assume radiant energy to be absorbed in accordance with the well-known exponential function of the thickness of the medium traversed, and that a similar relation having a larger exponent holds for the removal of heat by evaporation, since the direct effect of the latter is confined to a comparatively thin surface layer, in spite of the mechanical disturbance usually present near the surface. It then follows that evaporation removes heat at a greater rate near the surface than can be directly supplied by radiation. This surface layer thus becomes colder than that underneath, and consequently tends to change places with it. This interchange may not be complete. That is, a fraction r of the cold upper layer may remain to mix with the fraction $(1-r)$ of the rising warmer layer. Similarly, the cold water replacing this warm layer tends to change places with the one underneath, and so on downward. Thus a convective circulation is generated consisting of the descent of relatively cold water elements, and the ascent of relatively warm ones in which the difference in temperature decreases as the depth increases

Two differential equations, one giving the rate of change of the temperature of the descending cold water, the other giving the temperature rate for the ascending warm water can be derived from these assumptions. Regarding the measured temperature as the mean of that of the intermixed warm and cold elements, a combination of the two differential equations into a single one can be obtained whose solution, subject to suitable boundary conditions gives the relation in such form as to admit of observational tests. The satisfactory qualitative agreement of one such solution with generally accepted facts led to preliminary estimates of the physical constants. The results thus found appear to justify an extended investigation of the theory.

[1] Presented before American Physical Society, St. Louis, December 30, 1919.